Support for Government Performance and Results Act (GPRA) Analysis

2013 DOE Hydrogen Program and Vehicle Technologies Annual Merit Review
May 16th, 2013

Project ID # VSS099

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Overview

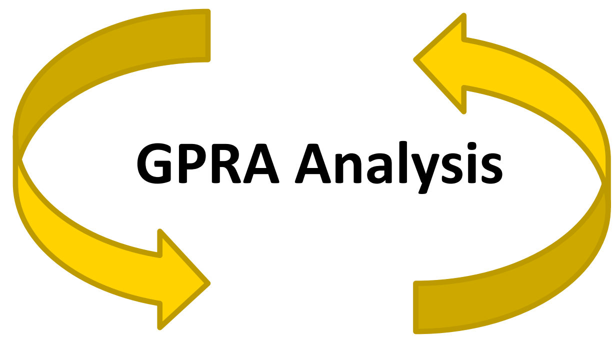
Timeline	Barriers*
Start Date: October 2012 End Date: September 2013 Percent Complete: 40%	• Risk aversion* • Constant advances in technology* • Cost* • Computational models, design, and simulation methodologies* • Complex benefits analysis *from 2011-2015 VTP MYPP

Budget	Partners
Total Project Funding (DOE) • $200,000 (Dave Anderson) • $150,000 (Jacob Ward, see VAN007) • $100,000 (Fred Joseck)	Formal Collaborator • ANL, ORNL, TA Engineering Interactions • All U.S. DRIVE Partners, outside companies (OEMs, suppliers…)

Objectives & Relevance

- Objective: calculate VTO benefits
  - Petroleum savings
  - GHG emissions reduction
  - Levelized cost of driving (light duty vehicles)
- Relevance:
  - Satisfy requirements of the Government Performance and Results Act
  - Link projected reductions in petroleum use and GHG emissions to VTP technical areas
  - Inform VTP managers about impacts of achieving technology targets

VTO Subprograms
- **Advanced Combustion**
- **Electrification**
- **Advanced Materials**
- **Fuels and Lubricants**



Macroeconomic indicators
- **petroleum consumption**
- **GHG emissions**
- **Fleet economy**

Objectives & Relevance (continued)

- Outputs inform regular VTO analytical product updates:
  - EERE annual scenario portfolio analysis
  - Levelized Cost of Driving Program Record
  - Well-to-Wheels Record
- The GPRA analysis process was used for evaluation of the VTO SuperTruck Project
- Results from GPRA analysis have been used in developing technology targets for VTP initiatives:
  - U.S. DRIVE Partnership
  - EV Everywhere Grand Challenge

Approach: VTO Scenario Comparison

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- Compare two scenarios to isolate the VTO technology portfolio:
  - Baseline "No-Program" scenario, which excludes all VTO-supported technology
  - Target scenario, in which vehicles meet VTP performance and cost targets:
    - Advanced Combustion
    - Electrification
    - Advanced Materials
    - Fuels and Lubricants

    (performance, cost)

Scenarios are a combination of times, powertrains, and uncertainties:

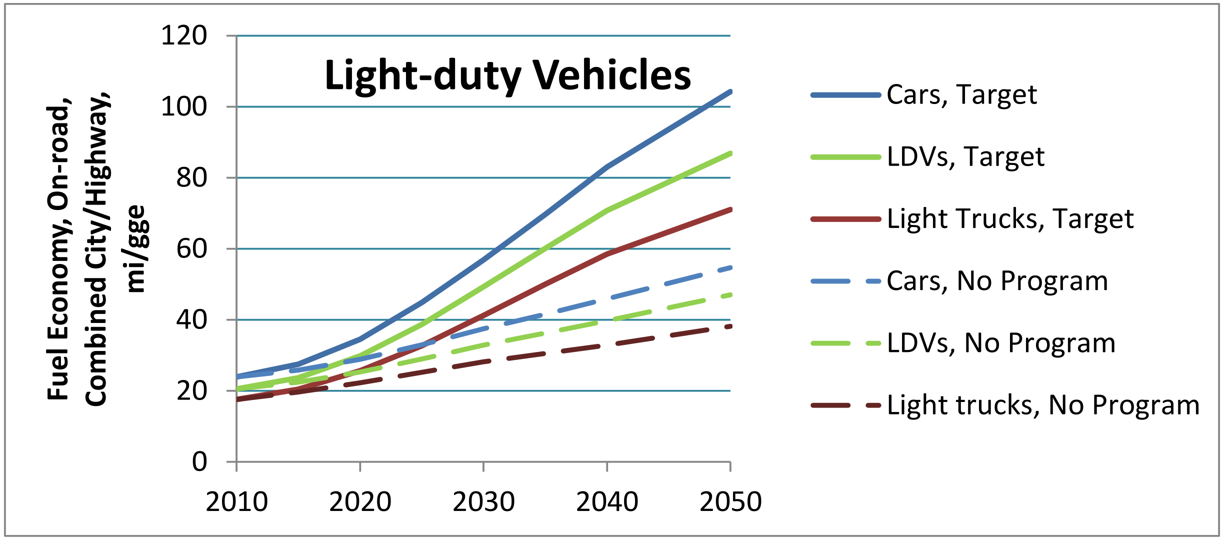
Time periods:	Powertrains:	Uncertainties:
• 2015	• Internal Combustion	• 10% (optimistic)
• 2020	• Hybrid	• 50% (mid-range)
• 2030	• Plug-in hybrid	• 90% (pessimistic)
• 2045	• Battery electric	
	• Fuel cell	

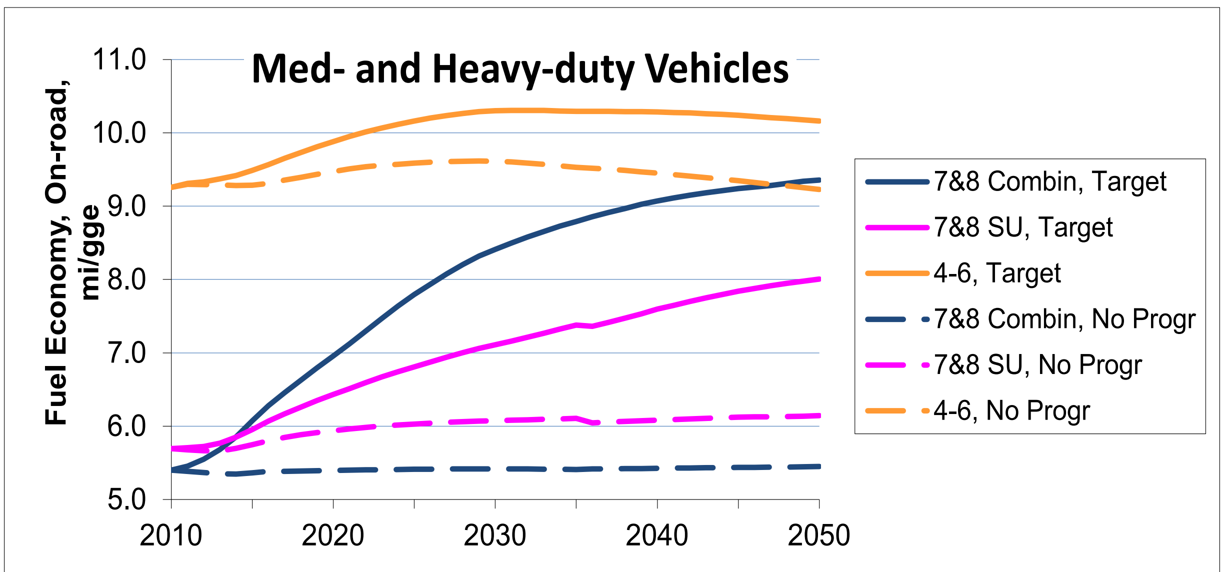
Approach: VTO Scenario Comparison

process	*approach*	data/output
Technology attribution	*Based on estimated contribution to reduction in fuel/mi by technology*	Strategic planning tools (fuel economy improvement by subprogram area, etc.)
Macro vehicle stock model	*Calculate fleet stock, and fuel use and GHG emissions by the fleet (VISION model using coefficients from GREET)*	Macro-level petroleum consumption, GHG emissions, and fleet fuel economies
Market penetration	*Estimate sales shares by vehicle class and drivetrain type (LDVs: MA3T; HDVs: TRUCK model)*	Market penetration scenarios
Vehicle modeling and simulation	*Convert performance/cost inputs to vehicle-level attributes, including price, fuel economy, etc. (LDVs: Autonomie, HTs: HTEB)*	Fuel economy, vehicle incremental cost

Autonomie: Vehicle simulation tool (ANL), see #VAN008; HTEB: Heavy Truck Energy Balance model (TA Engineering), : MA^{3}T: Market Acceptance of Advanced Automotive Technologies (ORNL), VISION: Stock/energy/Emissions accounting model (ANL), see #VAN006 , GREET: Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation model, see #VAN002

Technical Accomplishments: Projected Fuel Economies





- **LDV fuel economy is projected to increase much faster in the Target case**

  → VTO technologies offer 50-85% improvements in fuel economy

- **Class 7&8 combination truck fuel economy is projected to increase much faster in the Target case**

  → VTO technologies offer 40-50% improvements in fuel economy

Technical Accomplishments: Market Projections

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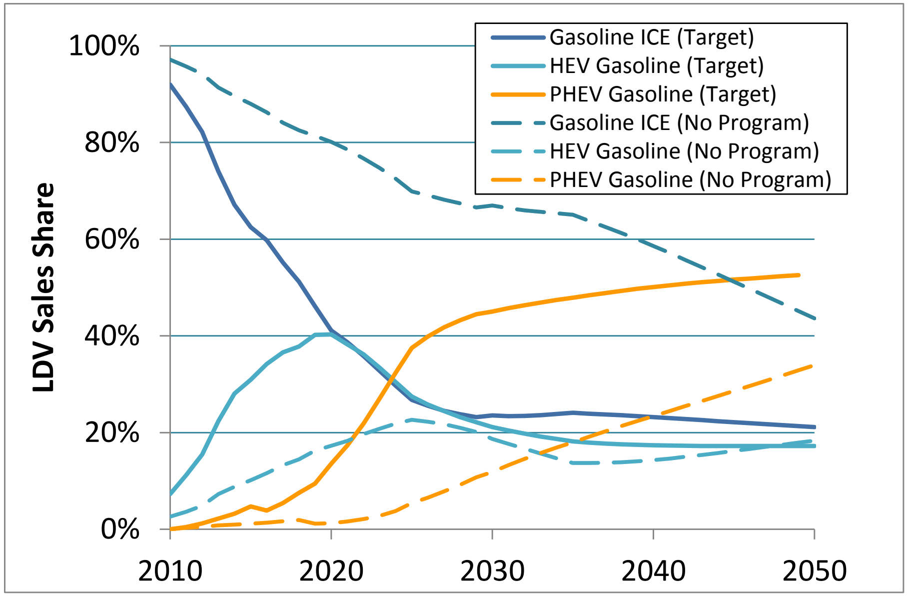

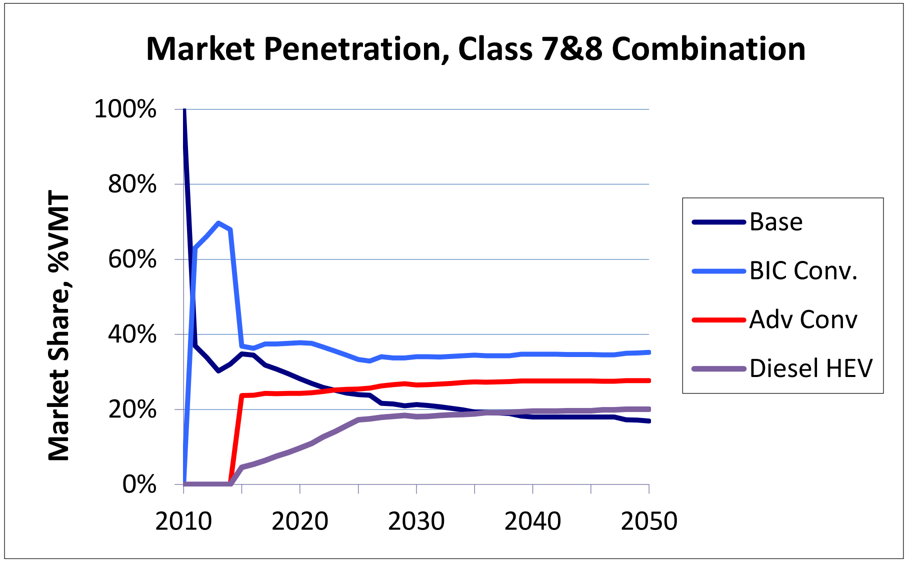

- **Much more rapid market penetration by HEVs and PHEVs in the "Target" case.**
- **Little penetration of all-electric of fuel cell vehicles in these cases (little pubic charging or hydrogen infrastructure assumed)**

- **Rapid penetration by best-in-class (BIC), since incremental cost is low**
- **Adv Conv. and HEVs grow more gradually in market share**

(Not shown: Analogous results for Class 7&8 Single Unit trucks and Class 4-6 trucks)

Technical Accomplishments: Projected Benefits

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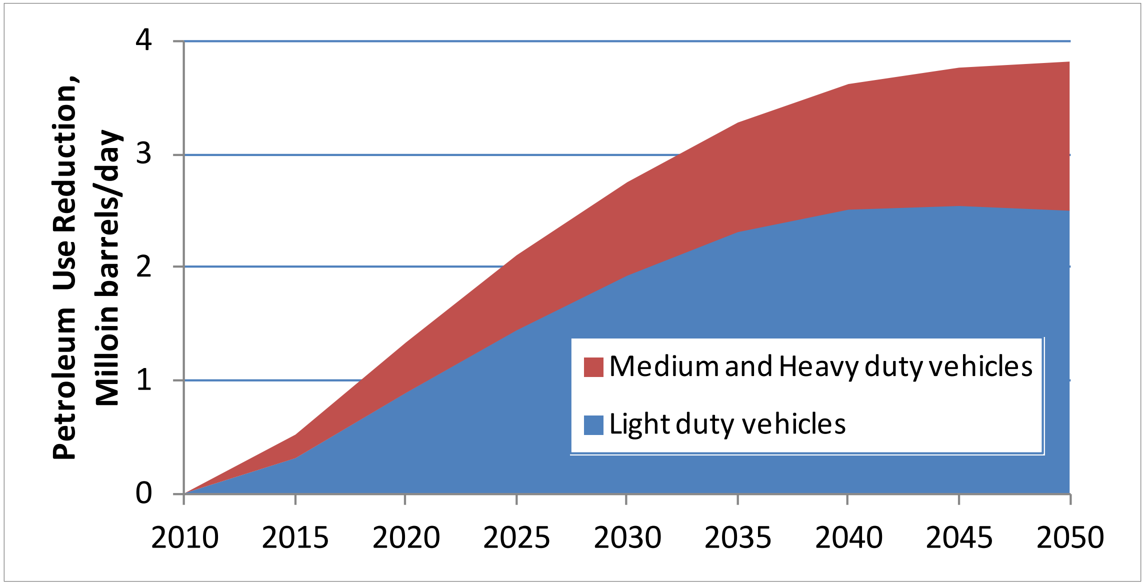
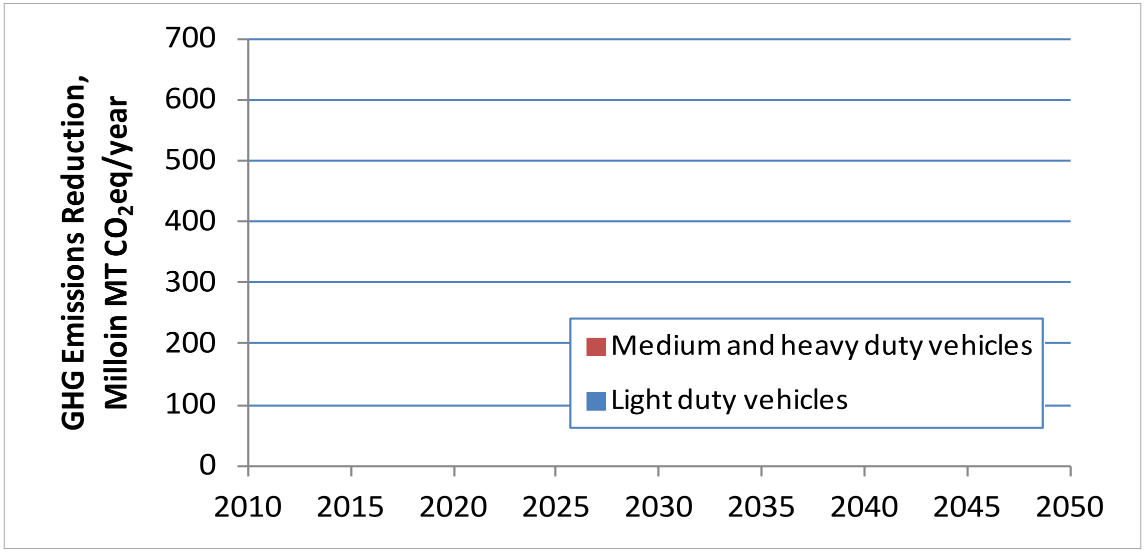
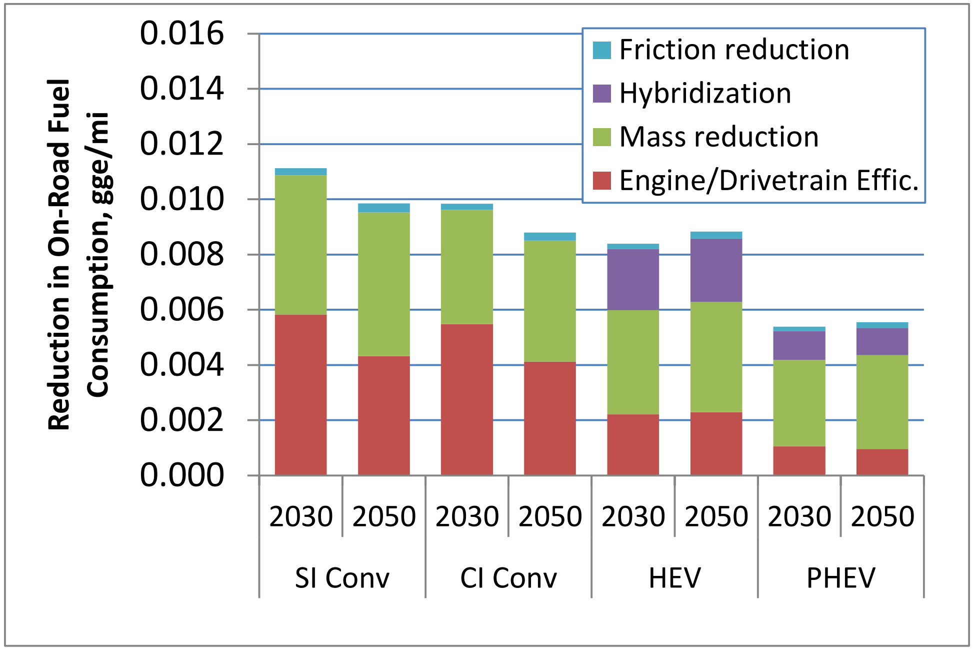


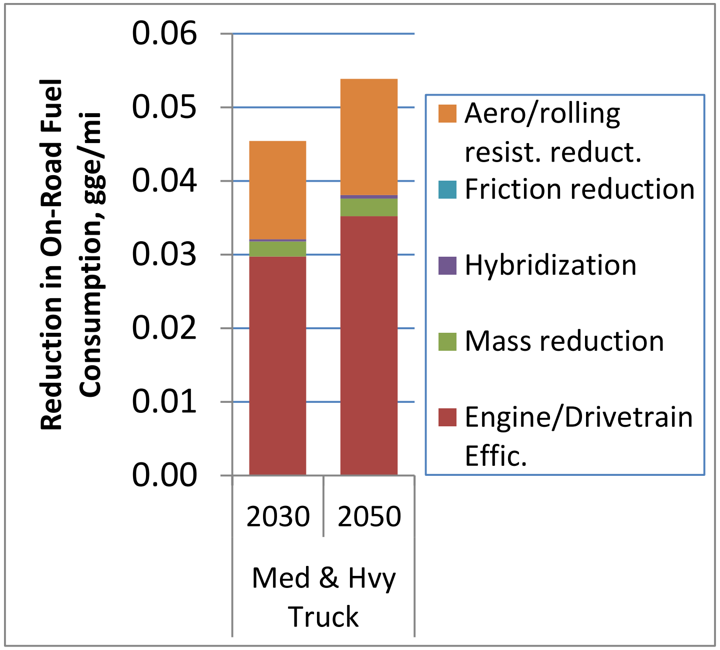
2050 Petroleum Use, Million barrels per day	No-Program	Target
LDVs	5.4	2.9
M + HDVs	4.3	2.9



Annual GHG Emissions, Million MT CO_2eq/yr	No-Program	Target
LDVs	1090	660
M + HDVs	730	490

Technical Accomplishments: Attribution of Benefits

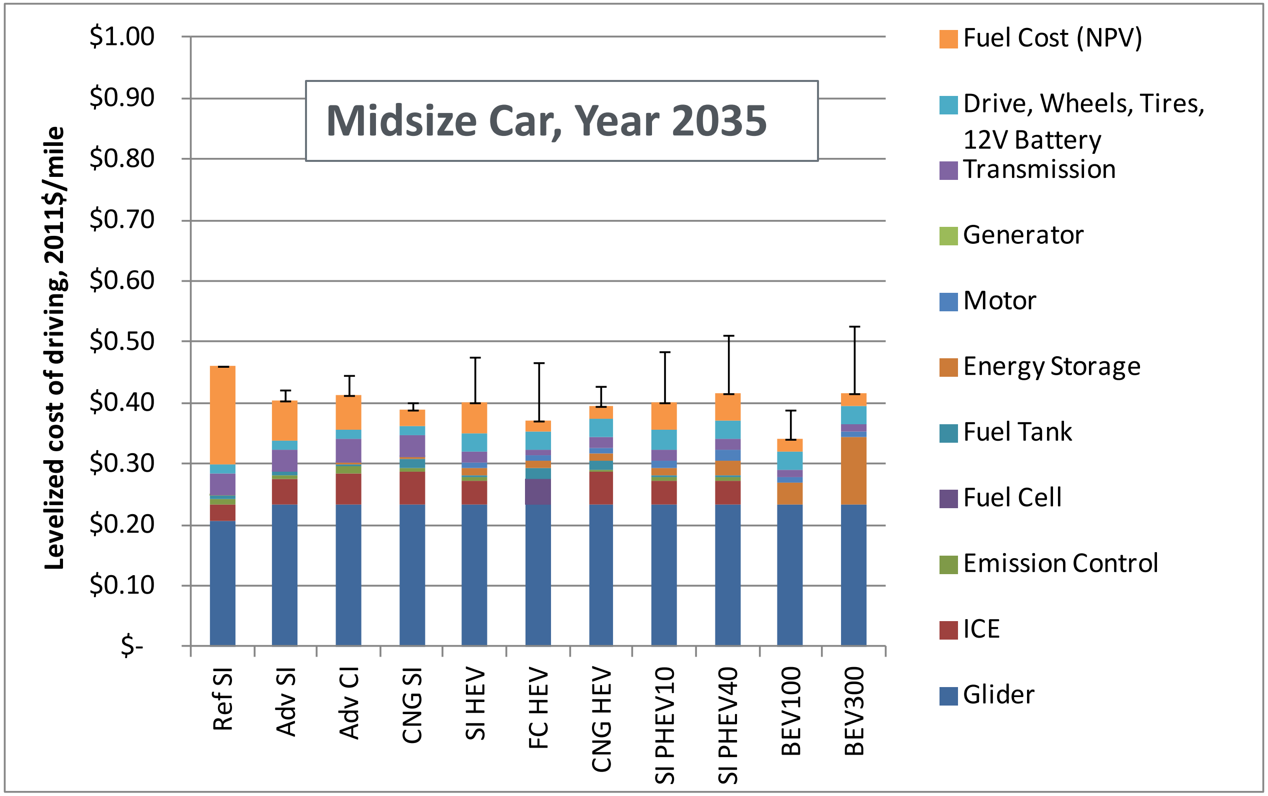




- Benefits from hybridization are significant for LD HEVs and PHEVs
- Benefits from increased engine and drivetrain efficiency are large for heavy and medium duty trucks

(No benefit attributed to reduction in aerodynamic or rolling resistance of LDVs , since VTP has no projects for these for LDVs.)

Technical Accomplishments: Levelized Cost



Levelized Cost of Driving = Purchase price of vehicle plus present value of fuel per lifetime vehicle-miles-traveled

Assuming:

- Fuel prices from AEO2012 High Oil Price Case
- 14,500 mi/year
- Ownership 5 year
- 7% discount rate
- Vehicle purchase and fuel costs only (no resale, insurance, maintenance costs)

- Cost per mile broken out by component shows tradeoff between cost of fuel and cost of advanced-technology components
- Error bars show range between Target Case and No Program Case
- HEV ad PHEVs are are cost-competitive with Advanced SI vehicle in the Target Case

Collaborations & Coordination

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Thanks to…

- T. Stephens, ANL, who leads LDV analysis and overall documentation (partner)
- A. Birky, TA Engineering, Inc., who perform simulations and analysis of medium and heavy trucks (partner)
- A. Rousseau, ANL, who performs light duty vehicle simulations (collaborator)
- Z. Lin (ORNL) on vehicle choice modeling (coordinating)
- EIA to maintain desired consistency with Annual Energy Outlook (coordinating)
- Cummins, Peterbilt, Detroit Diesel, Daimler, Navistar and Volvo to analyze new technologies for heavy trucks (coordinating)

Future Work

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Remainder of FY13

- Establish baseline case using AEO 2013
- Model/simulate vehicle performance and costs
- Project market shares and stock
- Calculate fuel use and emissions for U.S. fleet
- Update modeling and simulation assumptions
  - Testing procedures and sizing algorithms
- Include energy balance for each vehicle on each cycle
- Create an outputs database that can be used for other studies (i.e. cost sensitivities)

Proposed future improvements

- Improve fidelity of models (under separate funding)
- Include other costs (maintenance, resale value, etc.) in levelized cost

Summary

Successful achievement of EERE-VTP technology goals is estimated to result in the following benefits:

		2030	2050
On-road fuel economy improvement (%)	LDVs	50%	85%
	HTs	40%	50%
Annual oil savings (million bpd)		2.8	3.8
Annual primary energy savings (quad/yr)		6.7	9.7
GHG emission reduction (million mt CO_2eq/yr)		400	580

Scenarios analyzed provide a cause-effect link between specific program targets and future benefits

- Benefits from hybridization are significant for LD HEVs and PHEVs
- Benefits from increased engine and drivetrain efficiency are large for heavy and medium duty trucks

Questions

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